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[TITLE OF THE INVENTION]

AN OPTICAL RECORDING MEDIUM AND A METHOD FOR MANUFACTURING AN OPTICAL RECORDING MEDIUM

[CLAIMS]

[Claim 1] An optical recording medium comprising at least a recording layer and a dielectric layer formed to be adjacent to the recording layer, the dielectric layer containing a material prepared by adding N_2 to an oxide.

[Claim 2] An optical recording medium in accordance with Claim 1, wherein the dielectric layer contains at least one of Ta_2O_5 and TiO_2.

[Claim 3] An optical recording medium in accordance with Claim 1 or 2, wherein the recording layer is constituted so that data can be recorded therein by projecting a laser beam having a wavelength of 380 nm to 450 nm thereonto.

[Claim 4] An optical recording medium in accordance with any one of Claims 1 to 3, wherein the recording layer includes at least a first reaction layer and a second reaction layer and is constituted so that data can be recorded therein by projecting a laser beam thereonto and mixing an element contained in the first reaction layer and an element contained in the second reaction layer.

[Claim 5] An optical recording medium in accordance with Claim 4, wherein the first reaction layer contains copper (Cu), aluminum (Al), zinc

(Zn) or silver (Ag) as a primary component and the second reaction layer contains silicon (Si), germanium (Ge) or tin (Sn) as a primary component.

[Claim 6] An optical recording medium in accordance with Claim 5, wherein the first reaction layer contains an additive.

[Claim 7] An optical recording medium in accordance with any one of Claims 1 to 6, wherein the optical recording medium has a configuration obtained by laminating a plurality of information recording layers each including the recording layer and the dielectric layer and wherein at least the dielectric layer included in the information recording layer closest to a light incidence plane contains a material prepared by adding N_2 to an oxide.

[Claim 8] A method for manufacturing an optical recording medium comprising at least a recording layer and a dielectric layer formed to be adjacent to the recording layer, the method for manufacturing an optical recording medium comprising a step of forming the dielectric layer by vapor-phase growth of an oxide in an atmosphere of a mixed gas containing N_2 gas.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and a method for manufacturing an optical recording medium and, in particular, to an optical recording medium in which data can be recorded by a user and a method for manufacturing such an optical recording

medium.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

[0003]

Data are ordinarily held in the ROM type optical recording medium using spirally formed pit trains formed in the substrate in the manufacturing process and data held by the optical recording medium can be reproduced by projecting a laser beam to pass along the spirally formed pit trains and detecting the amount of the reflected laser beam.

[0004]

To the contrary, the write-once type optical recording medium or data rewritable type optical recording medium is provided with a recording layer containing an organic dye or a phase change material on a substrate of the medium and is constituted to record data therein by projecting a laser beam whose intensity is modulated onto the recording layer of the medium so as to pass along a groove and/or land spirally formed on the substrate of the medium, thereby chemically and/or physically changing the organic dye or the phase change material to form a number of pits (recording marks). In the case where data recording in

the write-once type optical recording medium or data rewritable type optical recording medium, in the manner of reproducing data from the ROM type optical recording medium, a laser beam is projected onto the recording layer to pass along the spirally formed groove and/or land and detecting the amount of the reflected laser beam.

[0005]

In a write-once type optical recording medium or a data rewritable type optical recording medium, a dielectric layer is generally formed in the vicinity of the recording layer, ordinarily adjacent to the recording layer, for chemically and/or physically protecting the recording layer and increasing modulation, namely, the difference between the reflection coefficient of regions of the recording layer where record marks are formed and that of regions thereof where record marks are not formed. Although various materials have been proposed as a material for forming such a dielectric layer so far, in order to improve optical characteristics of the optical recording medium, it is required for the material for forming such a dielectric layer to have a high refractive index *n* and a low extinction coefficient *k*. Specifically, in the case where the material has a high refractive index *n*, since it becomes easy to control the optical property of the dielectric layer, it is possible to increase modulation and in the case where the material has a low extinction coefficient *k*, since the energy of a laser beam absorbed in the dielectric layer is decreased, it is possible to increase the recording sensitivity of the optical recording medium and since an amount of light absorbed in the dielectric layer is decreased, it is possible to prevent the reflective coefficient of the dielectric layer from being lowered.

[0006]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

However, since the refractive index n and the extinction coefficient k of a conventional dielectric layer greatly depend on the wavelength of the incident light, the refractive index n of the dielectric layer becomes low or the extinction coefficient k of the dielectric layer becomes high depending upon the wavelength of the laser beam used for recording and reproducing data and, as a result, the optical characteristics of the optical recording medium are sometimes degraded. In particular, the extinction coefficients k of some metal oxides become higher with shorter laser beam wavelength and, therefore, if a dielectric layer is formed of such an oxide in a next-generation type optical recording medium in which data are recorded and reproduced using a laser beam in the blue wavelength band, it will be impossible to obtain excellent optical characteristics, namely, high modulation and high recording sensitivity.

[0007]

It is therefore an object of the present invention is to provide an optical recording medium which exhibits excellent optical characteristics with respect to a laser beam of desired wavelength used for recording data and reproducing data, and a method for manufacturing the same.

[0008]

It is another object of the present invention is to provide an optical recording medium which exhibits excellent optical characteristics with respect to a laser beam in the blue wavelength band used for recording data and reproducing data and a method for manufacturing the same.

[0009]

[MEANS FOR SOLVING THE PROBLEMS]

The inventors of the present invention vigorously pursued a study

for obtaining a dielectric layer having a high refractive index *n* and a low extinction coefficient *k* and, as a result, made the discovery that it was possible to vary the dependency of the refractive index *n* and the extinction coefficient *k* on the wavelength of a laser beam by adding N_2 to an oxide used for forming a dielectric layer. The present invention is based on this technical discovery and an optical recording medium according to the present invention is characterized in that the optical recording medium comprises at least a recording layer and a dielectric layer formed so as to be adjacent to the recording layer and that the dielectric layer contains a material prepared by adding N_2 to an oxide.

[0010]

According to the present invention, since the dielectric layer contains a material prepared by adding N_2 to an oxide, the optical recording medium can exhibit excellent optical characteristics with respect to a laser beam of desired wavelength used for recording data and reproducing data.

[0011]

More specifically, since the refractive index *n* and the extinction coefficient *k* of some oxides greatly depend on the wavelength of the incident light, the refractive index *n* of the dielectric layer becomes low or the extinction coefficient *k* of the dielectric layer becomes high depending upon the wavelength of the laser beam used for recording and reproducing data. However, in the case where N_2 is added to the oxide like the present invention, since the dependency of the refractive index *n* and the extinction coefficient *k* on the wavelength of a laser beam is varied in accordance with the amount of N_2 to be added, the optical recording medium can exhibit excellent optical characteristics with respect to a laser beam of desired wavelength used for recording data

and reproducing data. As described above, in the case where the material used for forming the dielectric layer has a high refractive index *n*, since it becomes easy to control the optical property of the dielectric layer, it is possible to increase modulation and it becomes easy to control the reflection coefficient of the dielectric layer and on the other hand, in the case where the material used for forming the dielectric layer has a low extinction coefficient *k*, it is possible to increase the recording sensitivity of the optical recording medium. Therefore, according to the present invention, it is possible to increase modulation and the recording sensitivity of an optical recording medium.

[0012]

Further, it is preferable for the dielectric layer to contain at least one of Ta_2O_5 and TiO_2. In the case where N_2 is added to Ta_2O_5 or TiO_2, reduction in the extinction coefficient *k* is pronounced and the refractive index *n* of the dielectric layer is markedly increased with respect to a laser beam in the blue wavelength band. Therefore, it is possible to further increase modulation and the recording sensitivity of an optical recording medium.

[0013]

Furthermore, it is preferable to record data in a recording layer by projecting a laser beam having a wavelength of 380 nm to 450 nm thereonto. In the case where a predetermined amount of N_2 is added to each of the above mentioned oxides, it exhibits a higher refractive index *n* and a lower extinction coefficient *k* with respect to light having a wavelength of 380 nm to 450 nm than the higher refractive index *n* and extinction coefficient *k* in the case where no N_2 is added thereto.

[0014]

Moreover, it is preferable for the recording layer to include at

least a first reaction layer and a second reaction layer and to be constituted so that data can be recorded therein by projecting a laser beam thereonto to mix an element contained in the first reaction layer and an element contained in the second reaction layer. In the case where the recording layer is constituted in this manner, it is possible to increase a reproduced signal.

[0015]

In this case, it is preferable for the first reaction layer to contain copper (Cu), aluminum (Al), zinc (Zn) or silver (Ag) as a primary component and for the second reaction layer to contain silicon (Si), germanium (Ge) or tin (Sn) as a primary component. In the case where the first reaction layer contains copper (Cu), aluminum (Al), zinc (Zn) or silver (Ag) as a primary component and the second reaction layer contains silicon (Si), germanium (Ge) or tin (Sn) as a primary component, it is possible to lower the noise level of a reproduced signal and decrease a load to the environment.

[0016]

Further, it is preferable for the first reaction layer to contain an additive. In the case where the first reaction layer contains an additive, it is possible to further lower the noise level of a reproduced signal and improve a long term storage reliability of an optical recording medium.

[0017]

Moreover, it is preferable for the optical recording medium to have a configuration obtained by laminating a plurality of information recording layers each including the recording layer and the dielectric layer and for at least the dielectric layer included in the information recording layer closest to a light incidence plane to contain a material prepared by adding N_2 to an oxide. Although it is required for the

information recording layer closest to a light incidence plane to have a high light transmittance, since the material prepared by adding N_2 to an oxide has a high refractive index *n*, it is possible to easily satisfy this requirement. Thus, it is possible to improve data recording characteristics and data reproduction characteristics of the lower recording layer(s).

[0018]

Further, a method for manufacturing an optical recording medium according to the present invention is directed to a method for manufacturing an optical recording medium comprising at least a recording layer and a dielectric layer formed to be adjacent to the recording layer and is characterized by comprising a step of forming the dielectric layer by vapor-phase growth of an oxide in an atmosphere of a mixed gas containing N_2 gas.

[0019]

According to the present invention, since N_2 is added to a dielectric layer to be formed in an amount corresponding to the amount of gas contained in the mixed gas used for vapor-phase growth of an oxide, it is possible to form a dielectric layer having a high refractive index *n* and a low extinction coefficient *k* with respect to a laser beam of desired wavelength used for recording data and reproducing data. Thus, it is possible to manufacture an optical recording medium which can exhibit high modulation and a high recording sensitivity.

[0020]

Here, in the present invention, the term "a recording layer and a dielectric layer are adjacent to each other" includes not only a case where the recording layer and the dielectric layer are in contact with each other but also a case where the recording layer and the dielectric layer are

formed via another layer.

[0021]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, preferred embodiments of the present invention will now be explained with reference to the accompanying drawings.

[0022]

Figure 1 (a) is a schematic partially cutaway perspective view showing an appearance of an optical recording disc which is a preferred embodiment of the present invention and Figure 1 (b) is a schematic enlarged cross-sectional view showing a section indicated by the symbol A in Figure 1 (a).

[0023]

An optical recording medium 10 shown in Figure 1 (a) and Figure 1 (b) has a disc-like shape having an outer diameter of about 120 mm and a thickness of about 1.2 mm and as shown in Figure 1 (b), the optical recording medium 10 includes a support substrate 11, a reflective layer 12, a second dielectric layer 13, a recording layer 14, a first dielectric layer 15 and a light transmission layer 16. The optical recording medium 10 according to this preferred embodiment is constituted so that data can be recorded therein and data can be reproduced thereform by projecting a laser beam onto a light incidence plane 16a constituted by the surface of the light transmission layer 16.

[0024]

The support substrate 11 is a disc-like substrate used for ensuring a thickness (about 1.2 mm) required for the optical recording medium 10. On one of the surfaces of the support substrate 11, grooves 11a and lands 11b are spirally formed from a portion in the vicinity of the center portion of the support substrate 11 toward the outer circumference thereof for

guiding a laser beam L. The support substrate 11 can be formed of various materials and the support substrate 11 can be formed of glass, ceramic or resin, for example. Among these, resin is preferably used for forming the support substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the support substrate 11 include polycarbonate resin, polyolefin resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin and polyolefin resin are most preferably used for forming the support substrate 11 from the viewpoint of easy processing and the like. In this embodiment, since a laser beam L is not transmitted through the support substrate 11 when data are recorded or to be reproduced, it is not required for the support substrate 11 to have a high light transmittance.

[0025]

The reflective layer 12 serves to reflect the laser beam L entering through the light transmission layer 16 so as to emit it from the light transmission layer 16. The thickness of the reflective layer 12 is preferably from 5 nm to 300 nm, more preferably from 20 nm to 200 nm. The material used to form the reflective layer 12 is not particularly limited insofar as it can reflect a laser beam L, and the reflective layer 12 can be formed of magnesium (Mg), aluminum (Al), titanium (Ti), chromium (Cr), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), germanium (Ge), silver (Ag), platinum (Pt), gold (Au) and the like. Among these materials, it is preferable to form the reflective layer 12 of a metal material having a high reflection characteristic, such as Al, Au, Ag, Cu or alloy containing at least one of these metals, such as alloy of Al and Ti. In the present invention, it is not absolutely necessary to provide a

reflective layer 12 in an optical recording medium but in the case where the reflective layer 12 is provided in an optical recording medium, a higher reproduced signal (C/N ratio) can be obtained by a multiple interference effect.

[0026]

The first dielectric layer 15 and the second dielectric layer 13 serve to protect the recording layer 14 formed therebetween. Degradation of data recorded in the recording layer 14 can be prevented over a long period by holding the recording layer 14 between the first dielectric layer 15 and the second dielectric layer 13.

[0027]

The first dielectric layer 15 and the second dielectric layer 13 also serve to enlarge the difference in optical characteristics between before and after recording data and for this purpose, it is necessary to select a material having a high refractive index n for forming the first dielectric layer 15 and the second dielectric layer 13. Moreover, since in the case where energy absorbed in the first dielectric layer 15 and the second dielectric layer 13 is large when a laser beam L is projected onto an optical recording medium, the recording sensitivity of the optical recording medium becomes lower, it is necessary to select a material having a low extinction coefficient k for preventing a large amount of energy from being absorbed in the first dielectric layer 15 and the second dielectric layer 13. Considering these requirements, in this embodiment, a material containing an oxide and added with N_2 is used for forming the first dielectric layer 15 and/or the second dielectric layer 13.

[0028]

It is preferable to employ an oxide of tantalum (Ta) or titanium (Ti), namely, Ta_2O_5 or TiO_2 as an oxide contained in the material as a

primary component. In the case where such an oxide is employed as a primary component of the first dielectric layer 15 and the second dielectric layer 13, it is possible to simultaneously suppress a load to the global environment and effectively protect the recording layer 14.

[0029]

Further, since N_2 is added to the above mentioned oxide to be contained in the first dielectric layer 15 and the second dielectric layer 13 as a primary element, the following technical advantages can be obtained. More specifically, since the refractive index n and the extinction coefficient k of a conventional dielectric layer greatly depend on the wavelength of the incident light, the refractive index n of the dielectric layer becomes low or the extinction coefficient k of the dielectric layer becomes high depending upon the wavelength of the laser beam used for recording and reproducing data and, as a result, the optical characteristics of the optical recording medium are sometimes degraded. However, in the case where N_2 is added to the above mentioned oxide, since the dependency of the refractive index n and the extinction coefficient k on the wavelength of a laser beam is varied in accordance with the amount of N_2 to be added, the optical recording medium can exhibit excellent optical characteristics with respect to a laser beam of desired wavelength used for recording data and reproducing data.

[0030]

Concretely, assuming that a refractive index and an extinction coefficient of the dielectric layer in the case where no N_2 is added to the above mentioned oxide are "n0" and "k0", respectively and that a refractive index and an extinction coefficient of the dielectric layer in the case where N_2 is added to the above mentioned oxide are "n1" and "k1", respectively, the value $(n0 - n1)$ tends to become small (become large in

the minus direction) and the value (k0 − k1) tends to become large as the wavelength of a laser beam becomes shorter and these tendencies are varied depending upon the added amount of N_2. Further, with respect to a laser beam L having a wavelength λ of 380 nm to 450 nm in the blue wavelength band used for recording data in and reproducing data from a next-generation type optical recording medium, the value (n0 − n1) can be made negative and/or the value (k0 − k1) can be made positive by adding a predetermined amount of N_2 to the above mentioned oxide. In other words, it is possible to obtain a higher refractive index *n* and lower extinction coefficient *k* than those in the case where no N_2 is added to the above mentioned oxide.

[0031]

In particular, the refractive index *no* of Ta_2O_5 in the case where no N_2 is added thereto is greatly lowered as the wavelength of a laser beam becomes shorter, while the refractive index *n1* of Ta_2O_5 in the case where a predetermined amount of N_2 is added thereto greatly increases as the wavelength of a laser beam becomes shorter. Further, the extinction coefficient *k* of Ta_2O_5 is lower as a whole in the case where a predetermined amount of N_2 is added thereto than in the case where no N_2 is added thereto, namely, *k0* > *k1* and this tendency becomes prominent as the wavelength of a laser beam becomes shorter. Furthermore, the refractive index *no* of TiO_2 in the case where no N_2 is added thereto is hardly changed depending upon the wavelength of a laser beam, while the refractive index *n1* of TiO_2 in the case where a predetermined amount of N_2 is added thereto increases as the wavelength of a laser beam becomes shorter. Moreover, the extinction coefficient *k* of TiO_2 is lower as a whole in the case where a predetermined amount of N_2 is added thereto than in the case where no

N_2 is added thereto, namely, $k0 > k1$ and this tendency becomes prominent as the wavelength of a laser beam becomes shorter.

[0032]

Thus, in the case where at least one of Ta_2O_5 and TiO_2 is employed as a primary component of the first dielectric layer 15 and/or the second dielectric layer 13 and a predetermined amount of N_2 is added thereto, it is possible to markedly improve the optical characteristics, namely, the refractive index n and the extinction coefficient k of the first dielectric layer 15 or the second dielectric layer 13 with respect to a laser beam L having a wavelength λ of 380 nm to 450 nm in the blue wavelength band in comparison with the case where no N_2 is added thereto.

[0033]

A preferable amount of N_2 to be added to an oxide depends upon the kind of the oxide to be contained in the first dielectric layer 15 or the second dielectric layer 13 as a primary component and a wavelength of a laser beam L used for recording and reproducing data. In the case where data are recorded and reproduced using a laser beam L having a wavelength of 380 nm to 450 nm in the blue wavelength band, when the oxide to be contained in the first dielectric layer 15 or the second dielectric layer 13 as a primary component is Ta_2O_5, it is preferable to add 1 to 12 atomic % of N_2 and it is more preferable to add 2 to 10 atomic % of N_2. On the other hand, when the oxide to be contained in the first dielectric layer 15 or the second dielectric layer 13 as a primary component is TiO_2, it is preferable to add 1 to 5 atomic % of N_2 and it is more preferable to add 2 to 4 atomic % of N_2. Here, the amount of N_2 added to the first dielectric layer 15 or the second dielectric layer 13 can be measured based on areas of respective peaks detected using an ESCA

(X-ray photoelectron spectroscopy: XPS).

[0034]

The first dielectric layer 15 and the second dielectric layer 13 may be formed of the same material or of different materials. It is most preferable for both of the first dielectric layer 15 and the second dielectric layer 13 to be formed of a material prepared by adding N_2 to an oxide as a primary component but only one of the first dielectric layer 15 and the second dielectric layer 13 may be formed of a material prepared by adding N_2 to an oxide as a primary component. At least one of the first dielectric layer 15 and the second dielectric layer 13 may have a multi-layered structure including a plurality of dielectric layers. In such a case, it is most preferable for all of the dielectric layers to be formed of a material prepared by adding N_2 to an oxide as a primary component but only part of the dielectric layers may be formed of a material prepared by adding N_2 to an oxide as a primary component.

[0035]

The thickness of the first dielectric layer 15 and the second dielectric layer 13 is not particularly limited but is preferably from 3 nm to 200 nm. If the first dielectric layer 15 or the second dielectric layer 13 is thinner than 3 nm, it is difficult to protect the recording layer 14 in a desired manner and enlarge the difference in the optical characteristics of the optical recording medium between before and after recording data. On the other hand, if the first dielectric layer 15 or the second dielectric layer 13 is thicker than 200 nm, it takes a long time to form the first dielectric layers 15 and the second dielectric layers 13, thereby lowering the productivity of the optical recording medium 10, and cracks may be generated in the optical recording medium 10 owing to stress present in the first dielectric layers 15 and/or the second dielectric layer 13.

[0036]

The recording layer 14 is a layer in which a recording mark is to be formed. Although not particularly limited, in the case where the optical recording medium 10 is constituted as a write-once type optical recording medium, it is preferable for the recording layer 14 to include a plurality of laminated reaction layers and in the case where the optical recording medium 10 is constituted as a data rewritable type optical recording medium, it is preferable for the recording layer 14 to be formed of a phase change material.

[0037]

In the case where the optical recording medium 10 is constituted as a write-once type optical recording medium and the recording layer 14 includes a plurality of reaction layers, as shown in Figure 2 (a), a reaction layer 21 and a reaction layer 22 are laminated in an unrecorded region of the recording layer 14. When the recording layer 14 is irradiated with a laser beam L having a predetermined power or more, as shown in Figure 2 (b), an element contained in the reaction layer 21 and an element contained in the reaction layer 22 are totally or partially mixed with each other, thereby forming a recording mark 20. Since the reflection coefficients with respect to a laser beam L are greatly different between a mixed region of the recording layer 14 where a recording mark 20 is formed and other regions (blank regions) of the recording layer 14, data can be recorded in and reproduced from the recording layer 14 utilizing this phenomenon. Recorded data are expressed by the length of a recording mark 20, namely, the length from the front edge of the recording mark 20 to the rear edge thereof, and the length of a blank region, namely, the length from the rear edge of the recording mark 20 to the front edge of a next recording mark 20. The record mark 20 and the

blank region are formed so as to have a length equal to an integral multiple of T, where T is a length corresponding to one cycle of a reference clock. Concretely, in the case where 1,7 RLL modulation code is employed, record marks 20 and blank regions having a length of 2T to 8T are formed.

[0038]

It is preferable for the reaction layer 21 to contain one element selected from the group consisting of aluminum (Al), silicon (Si), germanium (Ge), carbon (C), tin (Sn), gold (Au), zinc (Zn), copper (Cu), boron (B), magnesium (Mg), titanium (Ti), manganese (Mn), iron (Fe), gallium (Ga), zirconium (Zr), silver (Ag), bismuth (Bi) and platinum (Pt) as a primary component and for the reaction layer 22 to contain as a primary component an element selected from this group and different from the element contained in the reaction layer 21 as a primary component. In particular, in order to suppress the noise level of a reproduced signal to a lower level, it is more preferable for one of the reaction layer 21 and the reaction layer 22 to contain copper (Cu), aluminum (Al), zinc (Zn) or silver (Ag) as a primary component and for the other of the reaction layer 21 and the reaction layer 22 to contain silicon (Si), germanium (Ge) or tin (Sn) as a primary component and it is most preferable for one of the reaction layer 21 and the reaction layer 22 to contain copper (Cu) as a primary component and for the other of the reaction layer 21 and the reaction layer 22 to contain silicon (Si) as a primary component. In this case, it is particularly preferable for the reaction layer 21 located on the side of the light transmission layer 16 to contain silicon (Si) as a primary component and for the reaction layer 22 located on the side of the support substrate 11 to contain copper (Cu) as a primary component. In the case where each of the reaction layer 21 and

the reaction layer 22 contains this element as a primary component, the noise level of a reproduced signal can be suppressed to a lower level and load to the environment can be prevented from being increased.

[0039]

Further, in the case where one of the reaction layer 21 and the reaction layer 22 contains copper (Cu) as a primary component, it is preferable to add aluminum (Al), zinc (Zn), tin (Sn), gold (Au) or magnesium (Mg) to the one of the reaction layer 21 and the reaction layer 22. Furthermore, in the case where one of the reaction layer 21 and the reaction layer 22 contains aluminum (Al) as a primary component, it is preferable to add magnesium (Mg), gold (Au), tin (Sn) or copper (Cu) to the one of the reaction layer 21 and the reaction layer 22. Moreover, in the case where one of the reaction layer 21 and the reaction layer 22 contains zinc (Zn) as a primary component, it is preferable to add magnesium (Mg), aluminum (Al) or copper (Cu) to the one of the reaction layer 21 and the reaction layer 22. Further, in the case where one of the reaction layer 21 and the reaction layer 22 contains silver (Ag) as a primary component, it is preferable to add copper (Cu) or palladium (Pd) to the one of the reaction layer 21 and the reaction layer 22. In the case where such an element is added, it is possible to suppress the noise level of a reproduced signal to a lower level and it is possible to improve a long term storage reliability of the optical recording medium 10.

[0040]

The smoothness of the surface 21b of the reaction layer 21 irradiated with the spot of the laser beam L becomes worse as the thickness of the recording layer 14 becomes thicker. As a result, the noise level of the reproduced signal becomes higher and the recording sensitivity is lowered. Thus, in order to improve the smoothness of the

surface 21b of the reaction layer 21, thereby suppressing the noise level of the reproduced signal and increasing the recording sensitivity, it is effective to set the thickness of the recording layer 14 thinner. However, in the case where the thickness of the recording layer 14 is too small, the change in optical constant between before and after recording data is small, so that a reproduced signal having high strength (C/N ratio) cannot be obtained. Moreover, it becomes difficult to control the thickness of the recording layer 14. Therefore, it is preferable for the thickness of the recording layer 14 to be formed so as to have a thickness of 2 nm to 40 nm, it is more preferable for it to be formed so as to have a thickness of 2 nm to 20 nm and it is particularly preferable for it to be formed so as to have a thickness of 2 nm to 15 nm.

[0041]

The individual thicknesses of the reaction layer 21 and the reaction layer 22 are not particularly limited but in order to sufficiently suppress the noise level of the reproduced signal, considerably improve the recording sensitivity and greatly increase the change in reflection coefficient between before and after irradiation with the laser beam L, the thickness of each of the reaction layer 21 and the reaction layer 22 is preferably from 1 nm to 30 nm. Further, it is preferable to define the ratio of the thickness of the reaction layer 21 to the thickness of the reaction layer 22 (thickness of the reaction layer 21 / thickness of the reaction layer 22) to be from 0.2 to 5.0.

[0042]

In the case where the optical recording medium 10 is constituted as a write-once type optical recording medium, the above described configuration of the recording layer 14 is only one example and the recording layer 14 may have a different configuration. For example, a

recording layer 14 may have a three-layer configuration including two reaction layers 21 and a reaction layer 22 formed between the two reaction layers 21 and may include a layer formed by mixing a material for forming the reaction layer 21 and a material for forming the reaction layer 22 between the reaction layer 21 and the reaction layer 22.

[0043]

On the other hand, in the case where the optical recording medium 10 is constituted as a data rewritable type optical recording medium and the recording layer 14 is formed of a phase change material, data are recorded in the recording layer 14 utilizing the difference in the reflection coefficients between the case where the recording layer 14 is in a crystal phase and the case where it is in an amorphous phase. The material for forming the recording layer 14 is not particularly limited but a material capable of changing from an amorphous phase to a crystal phase in a short time, namely, a material having a short crystallization time, is preferable in order to enable direct overwriting of data at a high velocity. Illustrative examples of materials having such a characteristic include a SbTe system material. As the SbTe system material, SbTe may be used alone or a SbTe system material to which additives are added in order to shorten time required for crystallization and improve the long-term storage reliability of the optical recording medium 10 may be used.

[0044]

Concretely, it is preferable to form the recording layer 14 of a SbTe system material represented by the compositional formula: $(Sb_xTe_{1-x})_{1-y}M_y$, where M is an element other than Sb and Te, x is equal to or larger than 0.55 and equal to or smaller than 0.9 and y is equal to or larger than 0 and equal to or smaller than 0.25, and it is more

preferable to form the recording layer 14 of a SbTe system material represented by the above mentioned compositional formula wherein x is equal to or larger than 0.65 and equal to or smaller than 0.85 and y is equal to or larger than 0 and equal to or smaller than 0.25.

[0045]

While M is not particularly limited, it is preferable for the element M to be one or more elements selected from the group consisting of indium (In), silver (Ag), gold (Au), bismuth (Bi), serene (Se), aluminum (Al), phosphorus (P), germanium (Ge), hydrogen (H), silicon (Si), carbon (C), vanadium (V), tungsten (W), tantalum (Ta), zinc (Zn), manganese (Mn), titanium (Ti), tin (Sn), palladium (Pd), nitrogen (N), oxygen (O) and rare earth elements in order to shorten time required for crystallization and improve the storage reliability of the optical recording medium 10. It is particularly preferable for the element M to be one or more elements selected from the group consisting of silver (Ag), indium (In), germanium (Ge) and rare earth elements for improving the storage reliability of the optical recording medium 10.

[0046]

The light transmission layer 16 serves to form a light incidence plane of a laser beam L and serve to transmit a laser beam L. The light transmission layer 16 preferably has a thickness of 10 µm to 300 µm. More preferably, the light transmission layer 16 has a thickness of 50 µm to 150 µm. The material used to form the light transmission layer 16 is not particularly limited insofar as it has a sufficiently high light transmittance with respect to the wavelength of a laser beam L used for recording and reproducing data but ultraviolet ray curable acrylic resin or ultraviolet ray curable epoxy resin is preferably used for forming the light transmission layer 16. Instead, the light transmission layer 16 may

be formed using a light transmittable sheet made of light transmittable resin and various kinds of adhesive agents or agglutinant agents.

[0047]

Next, a method for fabricating the optical recording medium 10 according to this preferred embodiment will be described below.

[0048]

Figure 3 is a flow chart showing the method for fabricating the optical recording medium 10 according to this preferred embodiment.

[0049]

The support substrate 11 having the groove 11a and the land 11d on the surface thereof is first fabricated by injection molding using a stamper (Step S1). It is not absolutely necessary to fabricate the support substrate 11 using injection molding and the support substrate 11 may be fabricated using another method such a 2P process.

[0050]

The reflective layer 12 is further formed on the surface of the support substrate 11 on which the groove 11a and the land 11d are formed (Step S2). The reflective layer 12 can be formed by a gas phase growth process using chemical species containing elements for forming the reflective layer 12. Illustrative examples of the gas phase growth processes include a sputtering process, a vacuum deposition process and the like. It is preferable to form the reflective layer 12 using a sputtering process.

[0051]

The second dielectric layer 13 is then formed on surface of the reflective layer 12 (Step S3). The second dielectric layer 13 can be formed by a gas phase growth process using an oxide to be contained in the second dielectric layer 13 as a primary component in an atmosphere of a

mixed gas containing N_2 gas. For Example, when the second dielectric layer 13 is formed by a sputtering process, the second dielectric layer 13 can be formed using a mixed gas of argon (Ar) gas and nitrogen (N_2) gas as sputtering gas and an oxide to be contained as a primary component in the second dielectric layer 13 as a target. The content of N_2 added to the oxide to be contained in the second dielectric layer 13 as a primary component can be controlled by controlling the amount of nitrogen (N_2) gas in the sputtering gas.

[0052]

The recording layer 14 is further formed on the second dielectric layer 13 (Step S4). The recording layer 14 can be also formed by a gas phase growth process using chemical species containing elements for forming the recording layer 14. When a recording layer 14 having a laminated structure including a reaction layer 21 and a reaction layer 22 (See Figure 2) is to be formed, the reaction layer 22 is formed on the second dielectric layer 13 by a gas phase growth process using chemical species containing elements for forming the reaction layer 22 and the reaction layer 21 is then formed on the reaction layer 22 by a gas phase growth process using chemical species containing elements for forming the reaction layer 21, thereby forming the recording layer 14 including the reaction layer 21 and the reaction layer 22.

[0053]

The first dielectric layer 15 is further formed on the recording layer 14 (Step S5). Similarly to the formation of the second dielectric layer 13, the first dielectric layer 15 can be formed by a gas phase growth process using an oxide to be contained in the second dielectric layer 13 as a primary component in an atmosphere of a mixed gas containing N_2 gas.

[0054]

Finally, the light transmission layer 16 is formed on the first dielectric layer 15 (Step S6). The light transmission layer 16 can be formed, for example, by applying an acrylic ultraviolet ray curable resin or epoxy ultraviolet ray curable resin adjusted to an appropriate viscosity onto the surface of the second dielectric layer 15 by a spin coating method or the like to form a coating layer and irradiating the coating layer with ultraviolet rays to cure the coating layer. Thus, the optical recording medium 10 was fabricated.

[0055]

Here, it is not absolutely necessary to fabricate the optical recording medium 10 using the above described method and the optical recording medium 10 can be fabricated using a known method.

[0056]

Next, the principle for recording data in the optical recording medium 10 will be described later.

[0057]

When data are to be recorded in the optical recording medium 10, the recording layer 14 is first irradiated via the light transmission layer 16 with a laser beam L whose power is modulated. At this time, it is preferable to project a laser beam L having a wavelength λ of 450 nm or shorter onto the optical recording medium 10 via an objective having a numerical aperture NA of 0.7 or more and it is more preferable to project a laser beam L having a wavelength λ of about 405 nm via an objective having a numerical aperture NA of about 0.85. Thus, it is preferable that λ/NA be equal to or smaller than 640 nm.

[0058]

In the case where the recording layer 14 has a laminated structure including the reaction layer 21 and the reaction layer 22, the

recording layer 14 is heated by the irradiation with the laser beam L and the element contained in the reaction layer 21 and the element contained in the reaction layer 22 are mixed with each other. As shown in Figure 2 (b), the region of the recording layer 14 where the element contained in the reaction layer 21 and the element contained in the reaction layer 22 are mixed with each other is used as a recording mark 20 and since the reflection coefficient of this region is different from those of other regions (blank regions), data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in the reflection coefficients.

[0059]

On the other hand, in the case where the recording layer 14 is formed of a phase change material, when a predetermined region of the recording layer 14 is heated by the irradiation with the laser beam L to a temperature equal to or higher than the melting point of the phase change material and quickly cooled, the region assumes an amorphous state. On the other hand, when a predetermined region of the recording layer 14 is heated by the irradiation with the laser beam L to a temperature equal to or higher than the crystallization temperature of the phase change material and gradually cooled, the region assumes a crystallized state. Since the reflection coefficient of the region assuming an amorphous state (which corresponds to a recording mark) is different from the reflection coefficient of the region assuming a crystallized state (which corresponds to a blank region), data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in the reflection coefficients.

[0060]

In this embodiment, since the recording layer 14 is sandwiched between the first dielectric layer 15 and the second dielectric layer 13

and as described above, the first dielectric layer 15 and/or the second dielectric layer 13 is formed of a material containing an oxide as a primary component and added with N_2, it is possible to increase modulation and the recording sensitivity of an optical recording medium 10.

[0061]

As described above, the optical recording medium 10 according to this preferred embodiment includes the recording layer 14 and the first dielectric layer 15 and the second dielectric layer 13 formed to be adjacent with the recording layer 14 and the first dielectric layer 15 and/or the second dielectric layer 13 is formed of a material prepared by adding N_2 to an oxide. Therefore, it is possible to particularly increase modulation and the recording sensitivity of an optical recording medium 10 when the wavelength of a laser beam L in blue wavelength band is used.

[0062]

The present invention has thus been shown and described with reference to specific embodiments. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0063]

For example, in the optical recording medium 10 according to the above described preferred embodiments, although the recording layer 14 is sandwiched between the first dielectric layer 15 and the second dielectric layer 13, one of the first dielectric layer 15 and the second dielectric layer 13 may be omitted.

[0064]

Further, although the optical recording medium 10 according to the above described preferred embodiments includes the reflective layer 12 formed on the support substrate 11, in the case where the difference between the level of the laser beam L reflected by a region where a record mark 20 is formed and that by an unrecorded region is considerably large, the reflective layer 12 may be omitted.

[0065]

Furthermore, although the explanation was made as to the next generation type optical recording medium including a very thin light transmission layer 16, an optical recording medium to which the present invention can be applied is not limited to such a next generation type optical recording medium. However, since the present invention is particularly effective when a laser beam L in the blue wavelength band is used for recording data and reproducing data, the present invention is particularly suitable for the next generation type optical recording medium 10 using a laser beam L in the blue wavelength band.

[0066]

Moreover, although the optical recording medium 10 according to the above described preferred embodiments includes a single recording layer 14, the present invention can be preferably applied to an optical recording medium having a laminated structure of a plurality of information recording layers.

[0067]

Figure 4 is a schematic cross-sectional view showing an optical recording medium 20 having a laminated structure of a plurality of information recording layers.

[0068]

As shown in Figure 4, the optical recording medium 30 includes a

support substrate 31 formed with grooves 31a and lands 31b, a transparent intermediate layer 32 formed with grooves 32a and lands 32b, a light transmission layer 33, an L0 layer 40 formed between the support substrate 31 and the transparent intermediate layer 32 and an L1 layer 50 formed between the transparent intermediate layer 32 and the light transmission layer 33. The L0 layer 40 constitutes an information recording layer far from a light incidence plane 33a and includes a reflective layer 41, a fourth dielectric layer 42, an L0 recording layer 43 and a third dielectric layer 44 laminated on the support substrate 31 in this order. Further, the L1 layer 50 constitutes an information recording layer far from a light incidence plane 33a and includes a reflective layer 51, a second dielectric layer 52, an L1 recording layer 53 and a first dielectric layer 54 laminated in this order from the side of the support substrate 31. Thus, the optical recording medium 30 includes two laminated information recording layers, namely, the L0 layer 40 and the L1 layer 50.

[0069]

In the optical recording medium 30 having the above described structure, it is possible to form the first dielectric layer 54, the second dielectric layer 52, the third dielectric layer 44 and the fourth dielectric layer 42 of a material prepared by adding N_2 to an oxide. In particular, in the case where the first dielectric layer 54 and/or the second dielectric layer 52 is formed of a material prepared by adding N_2 to an oxide, since the first dielectric layer 54 and/or the second dielectric layer 52 has a high refractive index n and a low extinction coefficient k, the light transmittance of the L1 layer 50 can be increased. Thus, according to this preferred embodiment, it is possible to not only obtain the technical advantages of the previous preferred embodiment but also improve data

recording characteristics and data reproduction characteristics of the L0 layer 40.

[0070]

[WORKING EXAMPLES]

Hereinafter, working examples will be set out in order to further describe the present invention concretely. However, the present invention is in no way limited to the working examples.

[0071]

Working Example 1

A polycarbonate substrate having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus provided with a target of Ta_2O_5 and a sputtering process was performed at a power of 800 W, thereby forming a dielectric layer having a thickness of 30 nm and containing Ta_2O_5 as a primary component on the surface of the polycarbonate substrate. A mixed gas of argon (Ar) gas and nitrogen (N_2) gas was employed as a sputtering gas and samples 1-1 to 1-6 were fabricated to give their dielectric layers different N_2 contents from each other by varying the ratio of argon (Ar) gas and nitrogen (N_2) gas in the mixed gas. The relationship between the ratio of argon gas and N_2 gas contained in the mixed gas and the N_2 content in the dielectric layer was measured and shown in Table 1. The amount of N_2 added to each of the dielectric layer was obtained by multiplying the peak areas of the 4f peak of tantalum (peak position: about 28.2 to 37.4 eV), the 1s peak of oxygen (peak position: about 523 to 543 eV) and the 1s peak of nitrogen (peak position: about 390 to 410 eV) measured by the ESCA (Electron Spectroscopy for Chemical Analysis), namely, XPS (X-ray photoelectron spectroscopy) by the corresponding sensitivity factors of the peaks, namely, 0.596 of that of the 4f peak of tantalum, 2.994 of that of the 1s

peak of oxygen and 4.505 of that of the 1s peak of nitrogen.

[0072]

[TABLE 1]

	Flow rate of Ar gas (sccm)	Flow rate of N_2 gas (sccm)	Amount of N_2 (atomic%)
Sample 1-1	55	0	0
Sample 1-2	50	5	3.3
Sample 1-3	45	10	6.1
Sample 1-4	40	15	8.4
Sample 1-5	30	25	11.3
Sample 1-6	20	35	12.1

Then, a laser beam having a wavelength of 405 nm and a laser beam having a wavelength of 680 nm were projected onto each of the samples 1-1 to 1-6, whereby the refractive index n and the extinction coefficient k thereof were measured and the relationship between the amount of N_2 added to the dielectric layers containing Ta_2O_5 as a primary component and the refractive index n of the dielectric layer and the relationship between the amount of N_2 added to the dielectric layers and the extinction coefficient k of the dielectric layer were obtained. The thus obtained relationship between the amount of N_2 added to the dielectric layers and the refractive index n of the dielectric layer is shown in Figure 5 and the relationship between the amount of N_2 added to the dielectric layers and the extinction coefficient k of the dielectric layer is shown in Figure 6.

[0073]

As shown in Figure 5, it was found that when N_2 was added to the dielectric layer containing Ta_2O_5 as a primary component, the refractive

index n of the dielectric layer with respect to the laser beam having a wavelength of 405 nm increased but the refractive index n of the dielectric layer with respect to the laser beam having a wavelength of 680 nm decreased. Even when the amount of N_2 added to the dielectric layer containing Ta_2O_5 as a primary component was varied, it was found that the refractive index n of the dielectric layer with respect to the laser beam having a wavelength of 405 nm increased but the refractive index n of the dielectric layer with respect to the laser beam having a wavelength of 680 nm decreased.

[0074]

On the other hand, as shown in Figure 6, it was found that when N_2 was added to the dielectric layer containing Ta_2O_5 as a primary component, both the extinction coefficient k of the dielectric layer with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient k of the dielectric layer with respect to the laser beam having a wavelength of 680 nm markedly decreased. Even when the amount of N_2 added to the dielectric layer containing Ta_2O_5 as a primary component was varied, it was found that both the extinction coefficient k of the dielectric layer with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient k of the dielectric layer with respect to the laser beam having a wavelength of 680 nm markedly decreased. Considering that the extinction coefficient k of the dielectric layer of the sample 1-1 added with no N_2 with respect to the laser beam having a wavelength of 405 nm was relatively high, it is reasonable to conclude that the extinction coefficient k of the dielectric layer can be greatly decreased by adding N_2 to the dielectric layer.

[0075]

Then, a laser beam was projected onto the sample 1-1 whose

dielectric layer was added with no N_2 and the sample 1-2 whose dielectric layer was added with 3.3 atomic % of N_2 and the refractive index n and the extinction coefficient k of each dielectric layer were measured while varying the wavelength of the laser beam in the range between 350 nm and 800 nm, whereby the relationship between the wavelength of the laser beam and the refractive index n of the dielectric layers and the relationship between the wavelength of the laser beam and the extinction coefficient k of the dielectric layers were obtained. The result of measurement of the relationship between the wavelength of the laser beam and the refractive index n of the dielectric layers is shown in Figure 7 and the result of measurement of the relationship between the wavelength of the laser beam and the extinction coefficient k of the dielectric layers is shown in Figure 8.

[0076]

As shown in Figure 7, it was found that the refractive index n of the sample 1-1 including the dielectric layer containing Ta_2O_5 as a primary component but no N_2 as an additive decreased as the wavelength of the laser beam became shorter, while the refractive index n of the sample 1-2 including the dielectric layer containing Ta_2O_5 as a primary component and 3.3 atomic % of N_2 as an additive increased as the wavelength of the laser beam became shorter and that the refractive index n of the sample 1-2 was higher than that of the sample 1-1 with respect to the laser beam having a wavelength equal to or shorter than about 470 nm.

[0077]

Further, as shown in Figure 8, it was found that the extinction coefficient k of the sample 1-1 including the dielectric layer containing Ta_2O_5 as a primary component but no N_2 as an additive increased as the

wavelength of the laser beam became shorter, while the extinction coefficient *k* of the sample 1-2 including the dielectric layer containing Ta_2O_5 as a primary component and 3.3 atomic % of N_2 as an additive was substantially constant even if the wavelength of the laser beam varied and that the extinction coefficient *k* of the sample 1-1 was higher than that of the sample 1-2 with respect to the laser beam having a wavelength of from 350 nm to 800 nm.

[0078]

Working Example 2

A polycarbonate substrate having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus provided with a target of TiO_2 and a sputtering process was performed at a power of 800 W, thereby forming a dielectric layer having a thickness of 30 nm and containing TiO_2 as a primary component on the surface of the polycarbonate substrate. A mixed gas of argon (Ar) gas and nitrogen (N_2) gas was employed as a sputtering gas similarly to Working Example 1 and samples 2-1 to 2-8 were fabricated to give their dielectric layers different N_2 contents from each other by varying the ratio of argon (Ar) gas and nitrogen (N_2) gas in the mixed gas. The relationship between the ratio of argon gas and N_2 gas contained in the mixed gas and the N_2 content in the dielectric layer was measured and shown in Table 2. The amount of N_2 added to each of the dielectric layer was obtained by multiplying the peak areas of the 2p peak of tantalum (peak position: about 443.8 to 473.8 eV), the 1s peak of oxygen (peak position: about 523 to 543 eV) and the 1s peak of nitrogen (peak position: about 390 to 410 eV) measured by the ESCA (Electron Spectroscopy for Chemical Analysis), namely, XPS (X-ray photoelectron spectroscopy) by the corresponding sensitivity factors of the peaks, namely, 0.596 of that of

the 4f peak of tantalum, 2.994 of that of the 1s peak of oxygen and 4.505 of that of the 1s peak of nitrogen.

[0079]

[TABLE 2]

	Flow rate of Ar gas (sccm)	Flow rate of N_2 gas (sccm)	Amount of N_2 (atomic%)
Sample 2-1	55	0	0
Sample 2-2	52	3	1.7
Sample 2-3	50	5	2.9
Sample 2-4	47	8	3.1
Sample 2-5	45	10	3.3
Sample 2-6	40	15	3.9
Sample 2-7	30	25	5.1
Sample 2-8	20	35	5.7

Then, a laser beam having a wavelength of 405 nm and a laser beam having a wavelength of 680 nm were projected onto each of the samples 2-1 to 2-8, whereby the refractive index n and the extinction coefficient k thereof were measured and the relationship between the amount of N_2 added to the dielectric layers containing TiO_2 as a primary component and the refractive index n of the dielectric layer and the relationship between the amount of N_2 added to the dielectric layers and the extinction coefficient k of the dielectric layer were obtained. The thus obtained relationship between the amount of N_2 added to the dielectric layers and the refractive index n of the dielectric layer is shown in Figure 9 and the relationship between the amount of N_2 added to the dielectric layers and the extinction coefficient k of the dielectric layer is shown in Figure 10.

[0080]

As shown in Figure 9, it was found that when N_2 was added to the dielectric layer containing TiO_2 as a primary component, the refractive index *n* of the dielectric layer with respect to the laser beam having a wavelength of 405 nm increased but the refractive index *n* of the dielectric layer with respect to the laser beam having a wavelength of 680 nm was substantially constant. Even when the amount of N_2 added to the dielectric layer containing TiO_2 as a primary component was varied, it was found that the refractive index *n* of the dielectric layer with respect to the laser beam having a wavelength of 405 nm increased and the refractive index *n* of the dielectric layer with respect to the laser beam having a wavelength of 680 nm was substantially constant.

[0081]

On the other hand, as shown in Figure 10, it was found that when N_2 was added to the dielectric layer containing TiO_2 as a primary component, both the extinction coefficient *k* of the dielectric layer with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient *k* of the dielectric layer with respect to the laser beam having a wavelength of 680 nm markedly decreased but that even if the amount of N_2 added to the dielectric layer containing TiO_2 as a primary component was increased, both the extinction coefficient *k* of the dielectric layer with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient *k* of the dielectric layer with respect to the laser beam having a wavelength of 680 nm hardly decreased but adversely increased.

[0082]

Then, a laser beam was projected onto the sample 2-1 whose dielectric layer was added with no N_2 and the sample 2-3 whose dielectric layer was added with 2.9 atomic % of N_2 and the refractive index *n* and

the extinction coefficient k of each dielectric layer were measured while varying the wavelength of the laser beam in the range between 350 nm and 800 nm, whereby the relationship between the wavelength of the laser beam and the refractive index n of the dielectric layers and the relationship between the wavelength of the laser beam and the extinction coefficient k of the dielectric layers were obtained. The result of measurement of the relationship between the wavelength of the laser beam and the refractive index n of the dielectric layers is shown in Figure 11 and the result of measurement of the relationship between the wavelength of the laser beam and the extinction coefficient k of the dielectric layers is shown in Figure 12.

[0083]

As shown in Figure 11, it was found that the refractive index n of the sample 1-1 including the dielectric layer containing TiO_2 as a primary component but no N_2 as an additive did not greatly change even if the wavelength of the laser beam became shorter, while the refractive index n of the sample 2-3 including the dielectric layer containing TiO_2 as a primary component and 2.9 atomic % of N_2 as an additive increased as the wavelength of the laser beam became shorter and the refractive index n thereof was very large with respect to the laser beam in the blue wavelength band.

[0084]

Further, as shown in Figure 12, it was found that both the extinction coefficient k of the sample 2-1 including the dielectric layer containing TiO_2 as a primary component but no N_2 as an additive and the extinction coefficient k of the sample 2-3 including the dielectric layer containing TiO_2 as a primary component and 2.9 atomic % of N_2 as an additive increased as the wavelength of the laser beam became shorter

and that the increase in the extinction coefficient k of the sample 2-1 including the dielectric layer containing TiO_2 as a primary component but no N_2 as an additive was more prominent that that of the sample 2-3 and the extinction coefficient k of the sample 2-3 was lower than that of the sample 2-1 irrespective of the wavelength of the laser beam.

[0085]

Working Example 3

Optical recording medium samples 3-1 and 3-2 having the same structure as that of the optical recording medium 10 shown in Figure 1 were fabricated as follows.

[0086]

A polycarbonate substrate having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus and a reflective layer 12 containing Ag as a primary component and having a thickness of 100 nm, a second dielectric layer 13 containing TiO_2 as a primary component and 2.9 atomic % of N_2 as an additive and having a thickness of 17 nm, a reaction layer 22 containing copper (Cu) as a primary component and 23 atomic % of aluminum (Al) and 13 atomic % of gold (Au) as additives and having a thickness of 5 nm, a reaction layer 21 containing silicon (Si) as a primary component and having a thickness of 5 nm, a first dielectric layer 15 containing TiO_2 as a primary component and 2.9 atomic % of N_2 as an additive and having a thickness of 17 nm were sequentially formed on the thus fabricated polycarbonate substrate using the sputtering process.

[0087]

Further, the first dielectric layer 15 was coated using the spin coating method with an acrylic ultraviolet curing resin to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby

curing the acrylic ultraviolet curing resin to form a light transmission layer having a thickness of 100 µm.

[0088]

Thus, the optical recording medium sample 3-1 was fabricated.

[0089]

On the other hand, a polycarbonate substrate having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus and a reflective layer 12 containing Ag as a primary component and having a thickness of 100 nm, a second dielectric layer 13 containing only TiO_2 and having a thickness of 20 nm, a reaction layer 22 containing copper (Cu) as a primary component and 23 atomic % of aluminum (Al) and 13 atomic % of gold (Au) as additives and having a thickness of 5 nm, a reaction layer 21 containing silicon (Si) as a primary component and having a thickness of 5 nm, a first dielectric layer 15 containing only TiO_2 and having a thickness of 23 nm were sequentially formed on the thus fabricated polycarbonate substrate using the sputtering process.

[0090]

Further, the first dielectric layer 15 was coated using the spin coating method with an acrylic ultraviolet curing resin to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby curing the acrylic ultraviolet curing resin to form a light transmission layer having a thickness of 100 µm.

[0091]

Thus, the optical recording medium sample 3-2 was fabricated.

[0092]

Here, the thicknesses of the first dielectric layer 15 and the second dielectric layer 13 were different between in the optical recording

medium samples 3-1 and 3-2 because they were optimized so as to obtain the highest modulation.

[0093]

Data were recorded in the optical recording medium samples 3-1 and 3-2 under the recording conditions at which the highest modulation could be obtained and the modulation was measured. The results of measurement of the highest modulation are shown in Table 3 together with the power Pw of the laser beam by which the highest modulation was obtained.

[0094]

[TABLE 3]

	Modulation(%)	Power of laser beam (mW)
Sample 3-1	60	8.2
Sample 3-2	52	11.0

As shown in Table 3, it was found that higher modulation was obtained with a laser beam having lower power in the optical recording medium sample 3-1 in which N_2 was added to the first dielectric layer 15 and the second dielectric layer 13 than was obtained in the optical recording medium sample 3-2 in which no N_2 was added to the first dielectric layer 15 and the second dielectric layer 13. Thus it was found that the modulation and the recording sensitivity of an optical recording medium can be improved by adding N_2 to the oxide contained in the first dielectric layer 15 and the second dielectric layer 13.

[0095]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, according to the present invention, since the

dielectric layer adjacent to the recording layer is formed of a material prepared by adding N_2 to an oxide, it is possible to increase modulation and the recording sensitivity of an optical recording medium. Further, since the improvement in the refractive index n and the extinction coefficient k of a dielectric layer by adding N_2 to the dielectric layer is prominent with respect to a laser beam having a wavelength of 380 nm to 450 nm in the blue wavelength band, the present invention can be particularly preferably applied to a next generation type optical recording medium in which data are recorded using a laser beam in the blue wavelength band and from which data are reproduced using a laser beam in the blue wavelength band.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 (a) is a schematic partially cutaway perspective view showing an appearance of an optical recording disc which is a preferred embodiment of the present invention and Figure 1 (b) is a schematic enlarged cross-sectional view showing a section indicated by the symbol A in Figure 1 (a).

[Figure 2]

Figure 2 (a) is a schematic cross-sectional view showing a region of a recording layer in which no data are recorded and Figure 2 (b) is a schematic cross-sectional view showing a region of a recording layer in which a recording mark 20 is formed.

[Figure 3]

Figure 3 is a flow chart showing the method for fabricating the optical recording medium 10 according to this preferred embodiment.

[Figure 4]

Figure 4 is a schematic cross-sectional view showing an optical recording medium 20 having a laminated structure of a plurality of information recording layers.

[Figure 5]

Figure 5 is a graph showing the relationship between the amount of N_2 added to a dielectric layer containing Ta_2O_5 as a primary component and the refractive index *n* of the dielectric layer.

[Figure 6]

Figure 6 is a graph showing the relationship between the amount of N_2 added to a dielectric layer containing Ta_2O_5 as a primary component the extinction coefficient *k* of the dielectric layer.

[Figure 7]

Figure 7 is a graph showing the relationship between the wavelength of a laser beam and the refractive index *n* of a dielectric layer containing Ta_2O_5 as a primary component.

[Figure 8]

Figure 8 is a graph showing the relationship between the wavelength of a laser beam and the extinction coefficient *k* of a dielectric layer containing Ta_2O_5 as a primary component.

[Figure 9]

Figure 9 is a graph showing the relationship between the amount of N_2 added to a dielectric layer containing TiO_2 as a primary component and the refractive index *n* of the dielectric layer.

[Figure 10]

Figure 10 is a graph showing the relationship between the amount of N_2 added to a dielectric layer containing TiO_2 as a primary component the extinction coefficient *k* of the dielectric layer.

[Figure 11]

Figure 11 is a graph showing the relationship between the wavelength of a laser beam and the refractive index *n* of a dielectric layer containing TiO_2 as a primary component.

[Figure 12]

Figure 12 is a graph showing the relationship between the wavelength of a laser beam and the extinction coefficient *k* of a dielectric layer containing TiO_2 as a primary component.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10, 30 ..... an optical recording medium

11, 31 ..... a support substrate

11a, 31a, 32a ..... a groove

11b, 31b, 32b ..... a land

12, 41, 51 ..... a reflective layer

13, 52 ..... a second dielectric layer

14, 43, 53 ..... a recording layer

15, 54 ..... a first dielectric layer

16 ..... a light transmission layer

16a, 33a ..... a light incidence plane

20 ..... a recording mark

21, 22 ..... a reaction layer

21b ..... a surface of a reaction layer 21

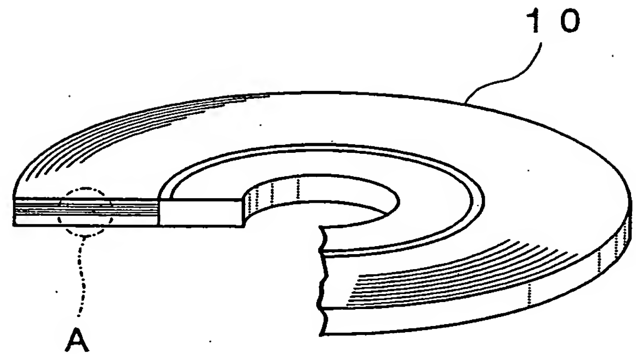
40 ..... an L0 layer

42 ..... a fourth dielectric layer

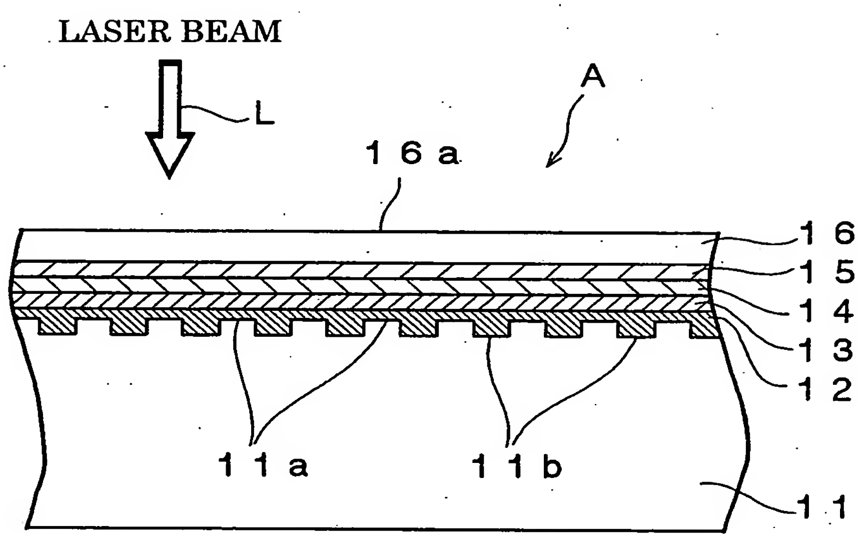
44 ..... a third dielectric layer

50 ..... an L1 layer

FIG. 1

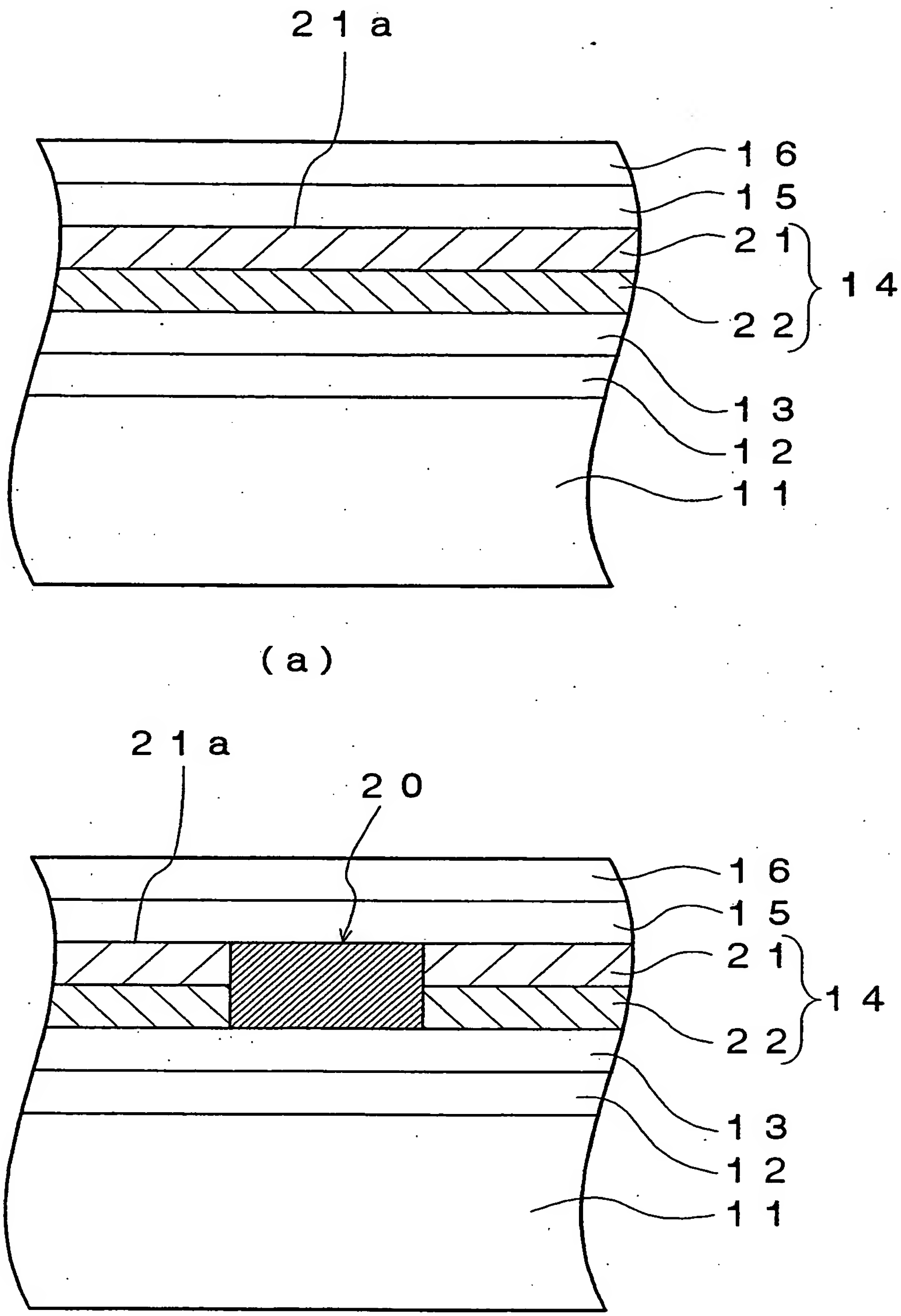


(a)



(b)

FIG. 2



(a)

(b)

FIG. 3

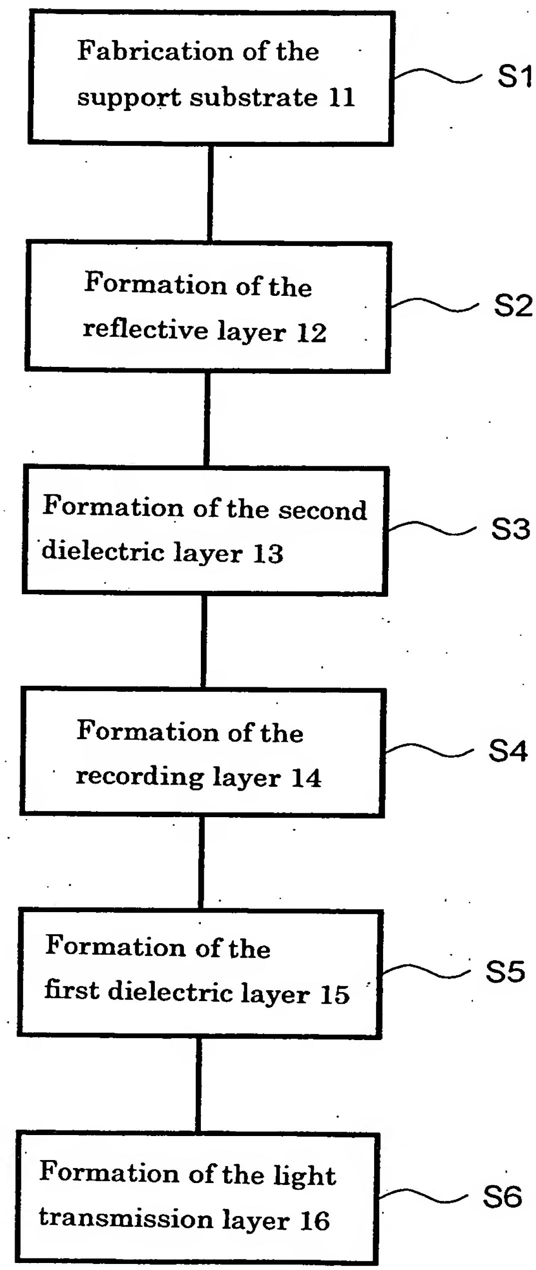

Fabrication of the support substrate 11
S1
Formation of the reflective layer 12
S2
Formation of the second dielectric layer 13
S3
Formation of the recording layer 14
S4
Formation of the first dielectric layer 15
S5
Formation of the light transmission layer 16
S6

FIG. 4

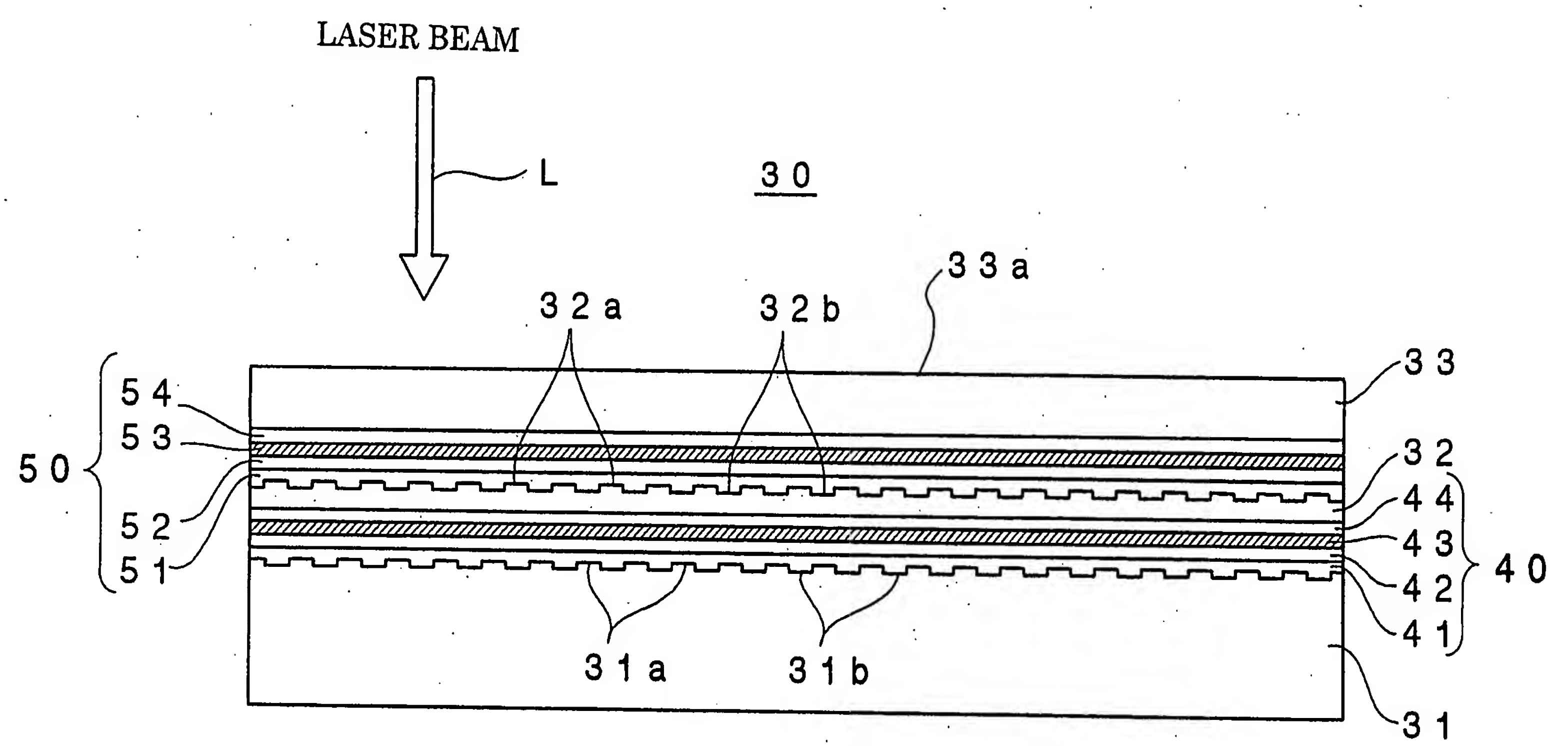

LASER BEAM
L
30
33a
32a
32b
33
32
44
43
42
41
40
31
54
53
52
51
50
31a
31b

FIG. 5

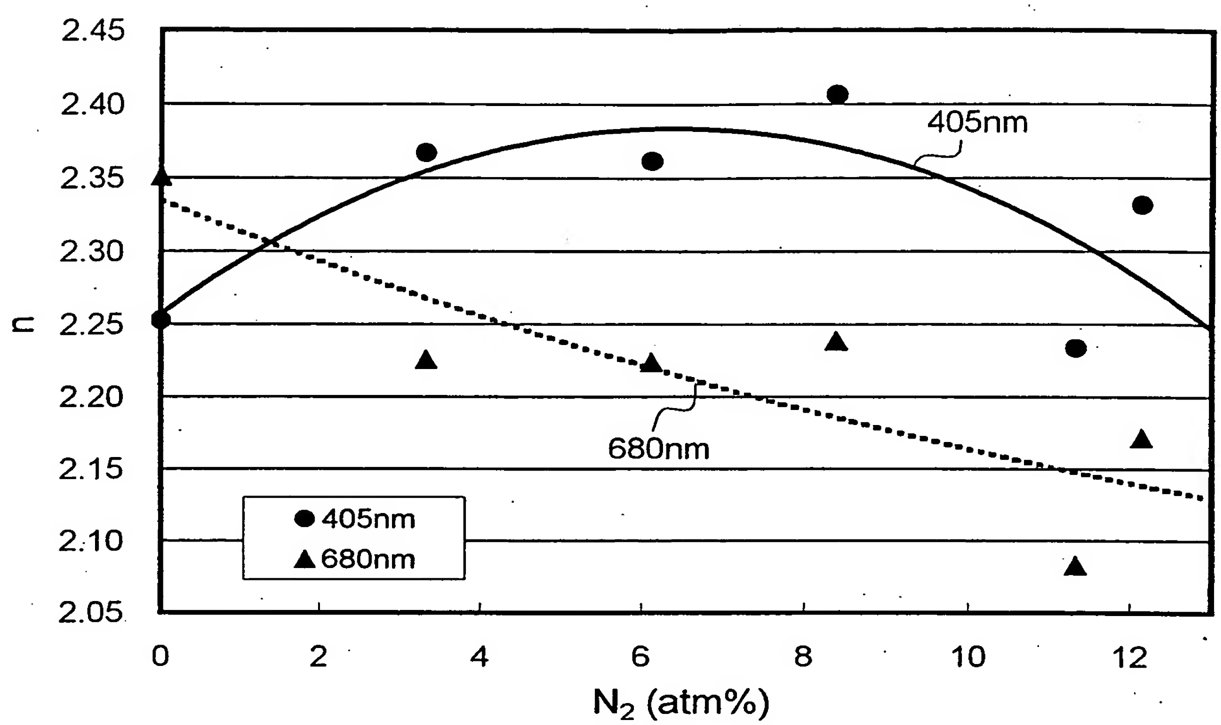

2.45
2.40
2.35
2.30
2.25
2.20
2.15
2.10
2.05
n
405nm
680nm
405nm
680nm
0
2
4
6
8
10
12
N2 (atm%)

FIG. 6

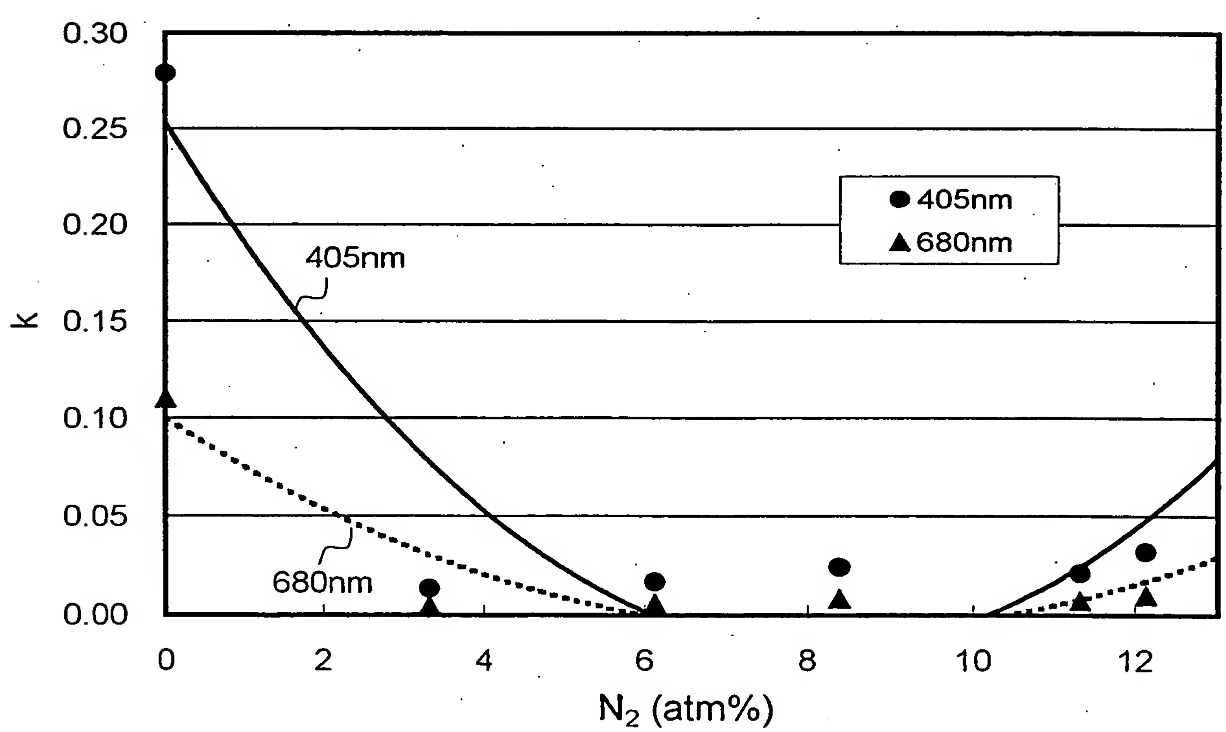

0.30
0.25
0.20
0.15
0.10
0.05
0.00
k
405nm
680nm
405nm
680nm
0
2
4
6
8
10
12
N2 (atm%)

FIG. 7

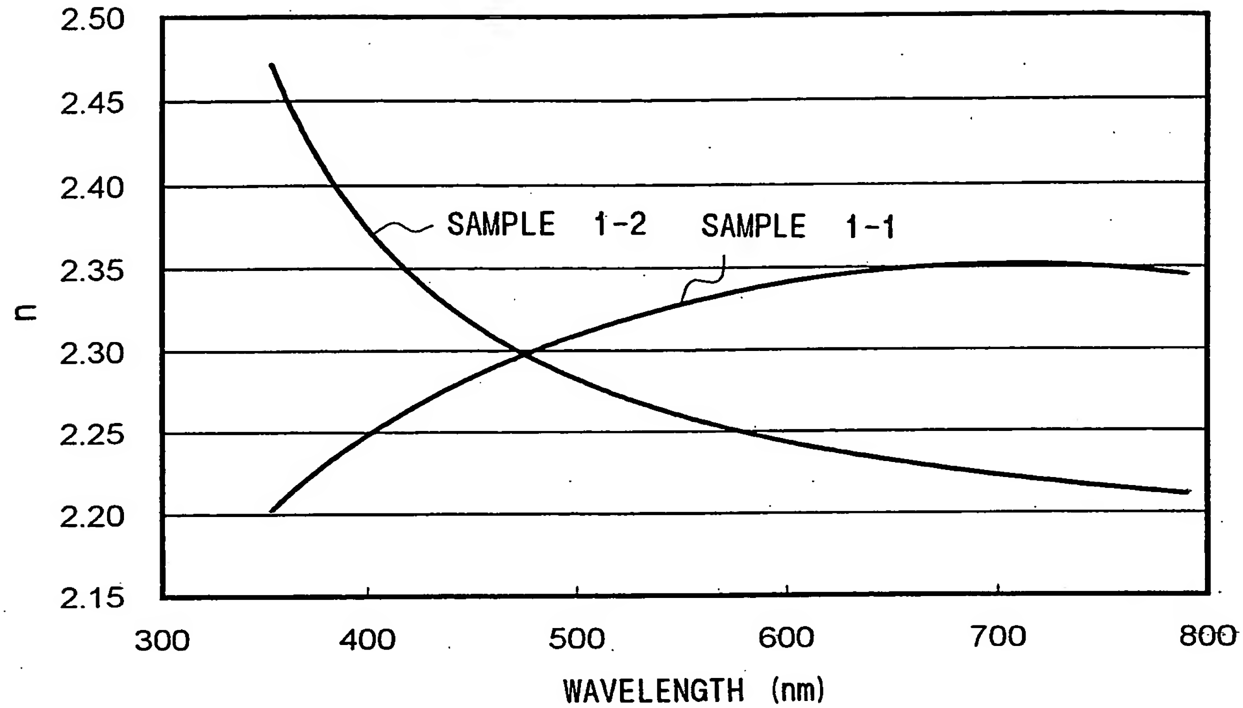

2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
n
SAMPLE 1-2
SAMPLE 1-1
300
400
500
600
700
800
WAVELENGTH (nm)

FIG. 8

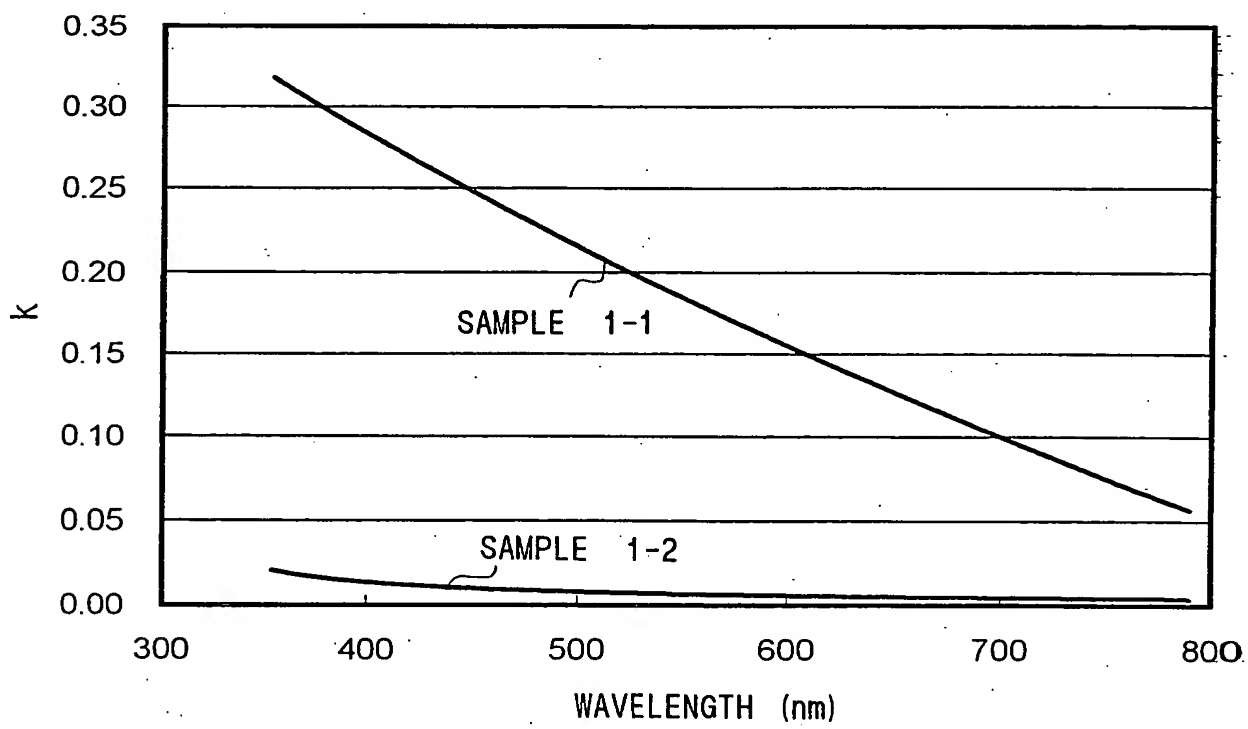
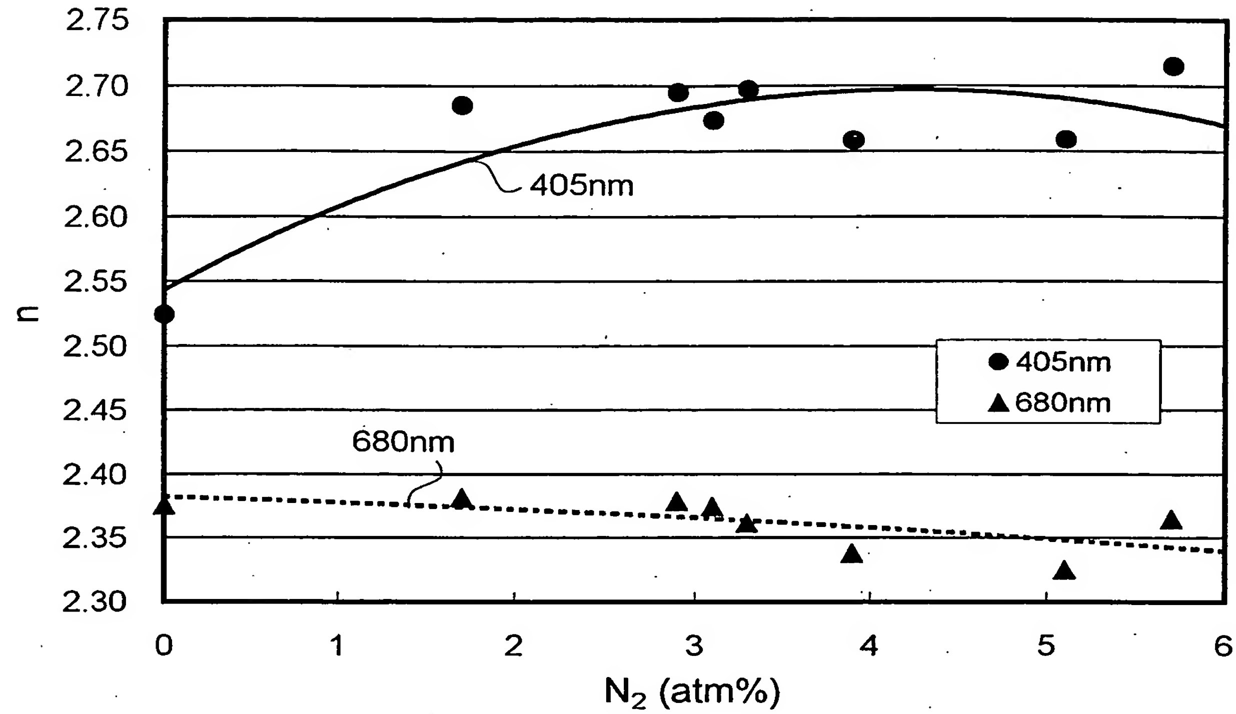
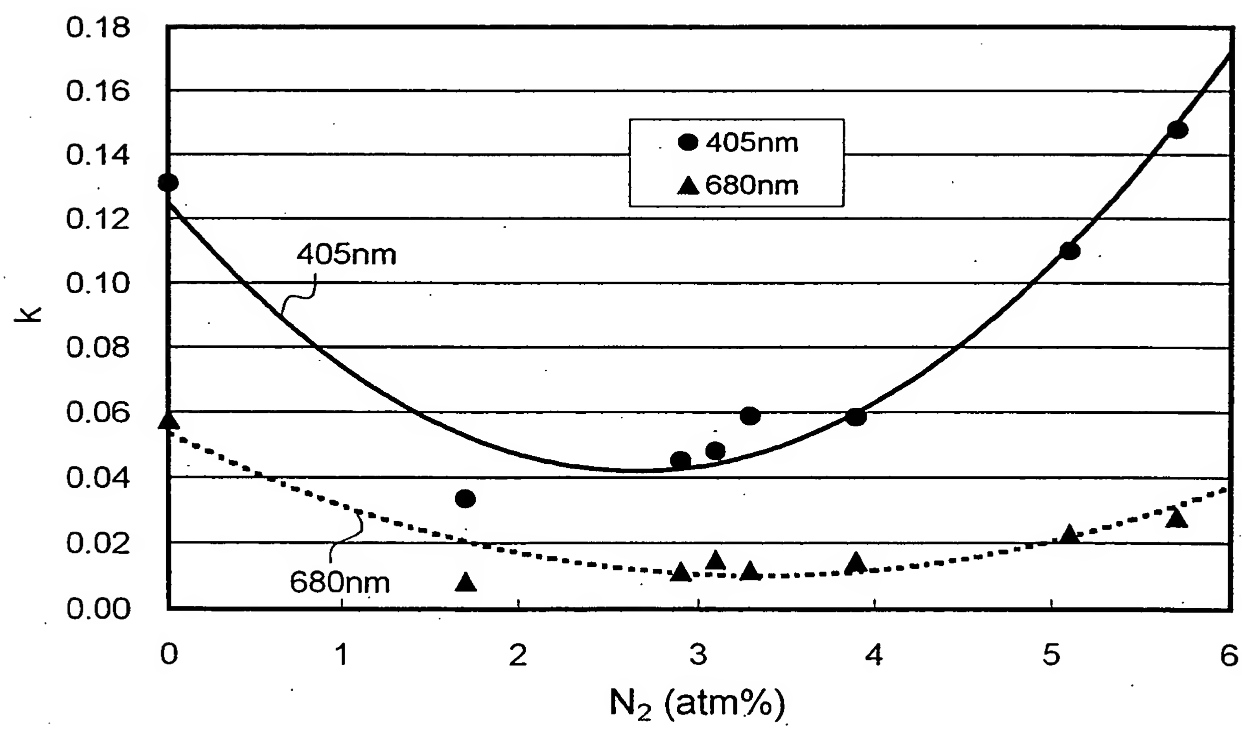

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
k
SAMPLE 1-1
SAMPLE 1-2
300
400
500
600
700
800
WAVELENGTH (nm)

FIG. 9



2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
n
405nm
680nm
405nm
680nm
0
1
2
3
4
5
6
N2 (atm%)

FIG. 10



0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
k
405nm
680nm
405nm
680nm
0
1
2
3
4
5
6
N2 (atm%)

FIG. 11

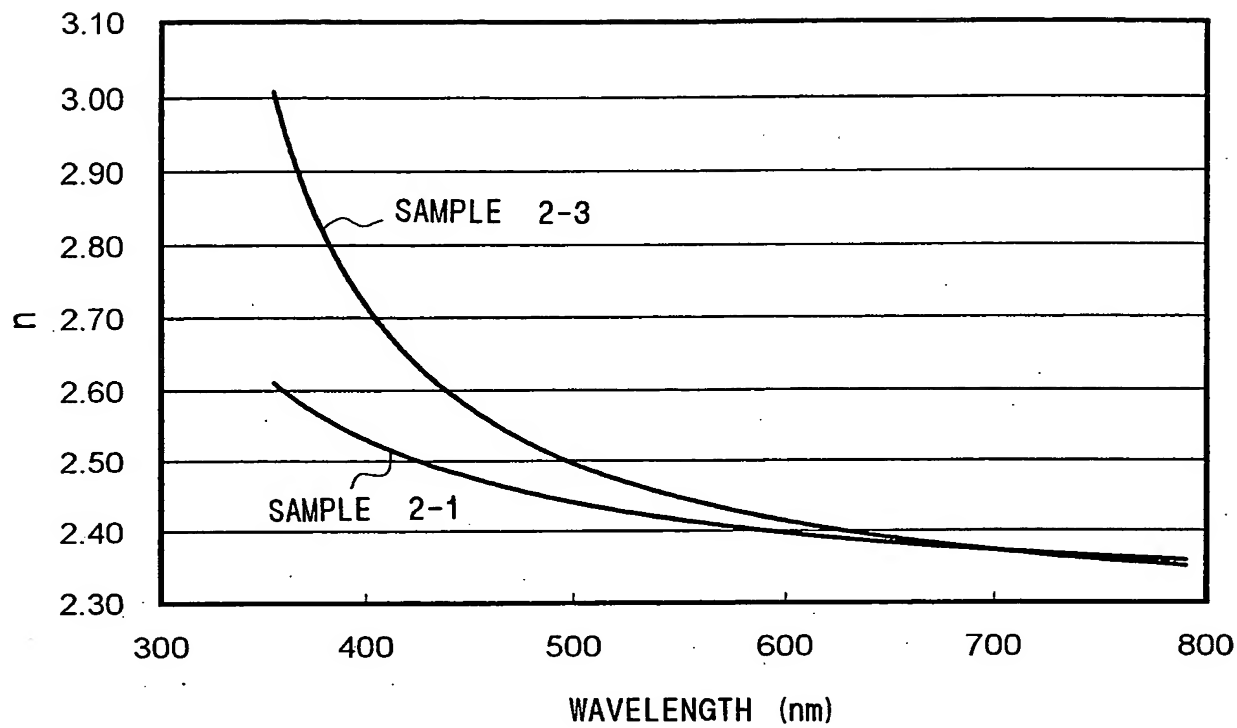
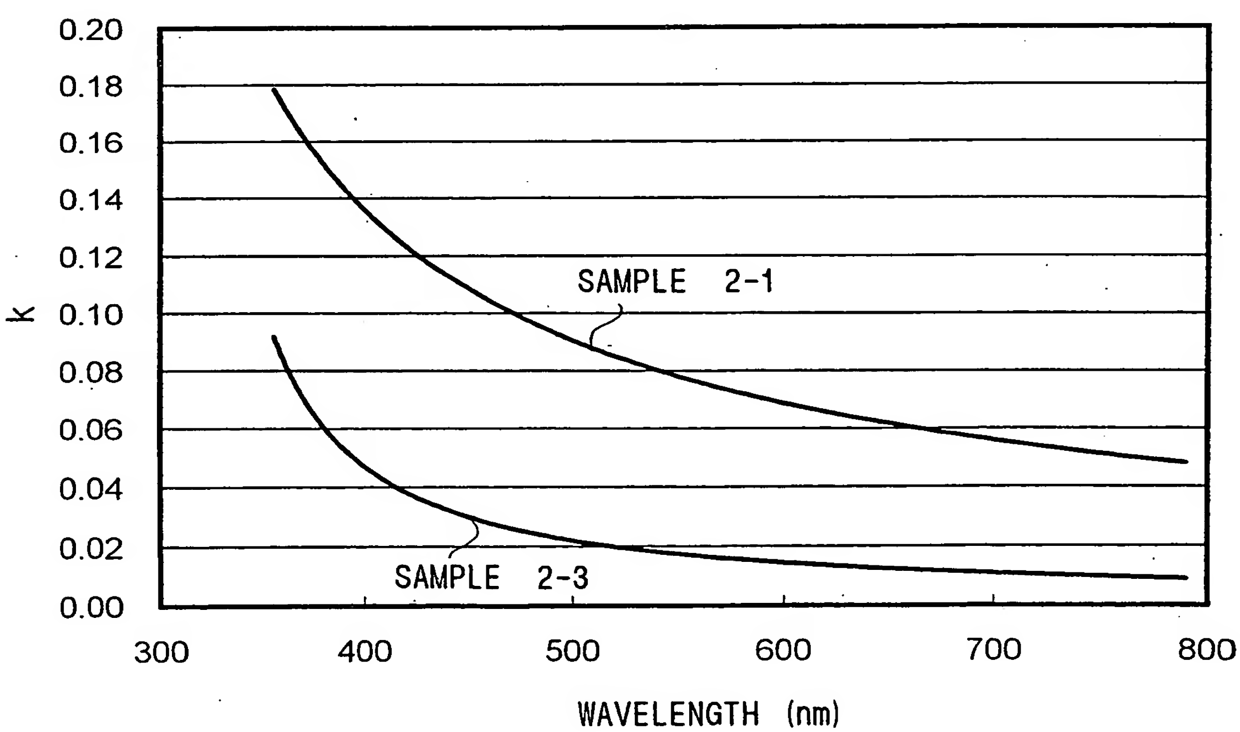

3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
n
SAMPLE 2-3
SAMPLE 2-1
300
400
500
600
700
800
WAVELENGTH (nm)

FIG. 12


0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
k
SAMPLE 2-1
SAMPLE 2-3
300
400
500
600
700
800
WAVELENGTH (nm)

[Name of Document] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problems]

It is an object of the present invention is to provide an optical recording medium which exhibits excellent optical characteristics with respect to a laser beam in the blue wavelength band.

[Solutions]

An optical recording medium according to the present invention includes at least a recording layer 14 and dielectric layers 13, 15 formed adjacent with the recording layer 14 and each of the dielectric layers 13, 15 contains a material obtained by adding N_2 to an oxide. It is preferable for each of the dielectric layers 13, 15 to contain at least one of Ta_2O_5 and TiO_2. In the case where N_2 is added to Ta_2O_5 or TiO_2, since the extinction coefficient k of the dielectric layer markedly decreases and the refractive index n of the dielectric layer with respect to a laser beam in the blue wavelength band is particularly increases, a dielectric layer having a high refractive index n and a low extinction coefficient k with respect to a laser beam in the blue wavelength band can be obtained. Thus, it is possible to obtain an optical recording medium which can exhibit high modulation and high recording sensitivity when data are recorded therein using a laser beam in the blue wavelength band.

[Selected Figure] Figure 1